WATER,WATER EVERYWHERE, BUT NOT A DROP TO DRINK… THE GLOBAL IMPACTS OF FRESH WATER

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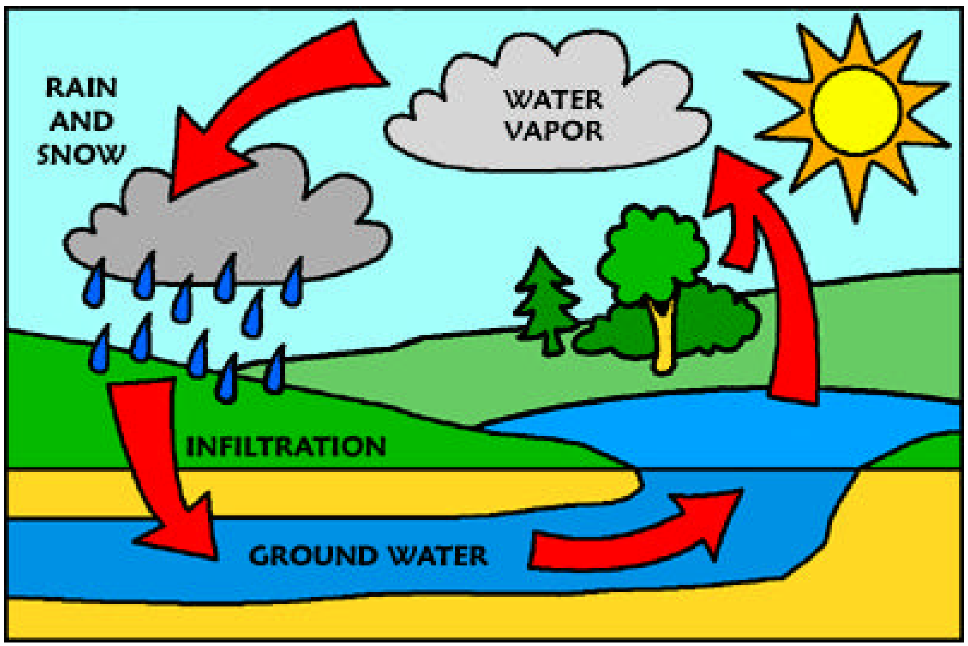
SOME WATER FACTS

Water is continually recycled in the Earth's hydrologic cycle.



Nearly 97% of the world's water is salt or otherwise undrinkable.

Another 2% is held in ice caps and glaciers.

1 Percent is available for agricultural, residential, manufacturing, and community needs.

Of all the freshwater that exists,
about 75 percent
is estimated to be stored
in polar ice and glaciers.

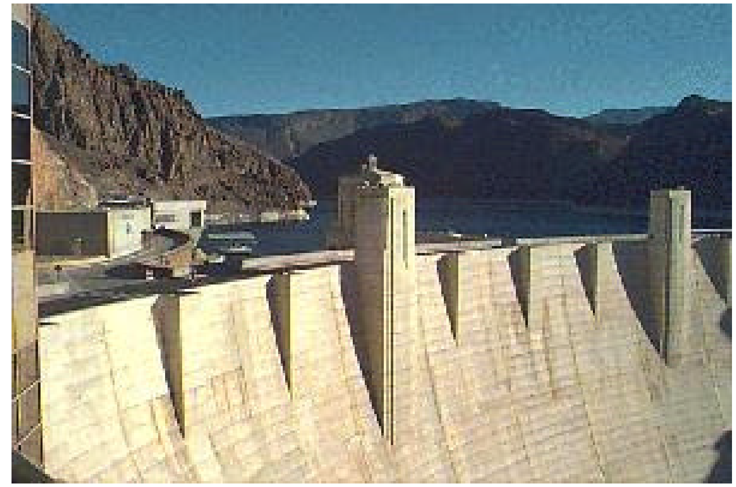
About 25 percent is estimated
to be stored as ground water.
Freshwater stored in rivers, lakes,
and as soil moisture amounts
to less than 1 percent of the world's
freshwater.

In a one hundred year period, an average water molecule spends 98 years in the ocean, 20 months as ice, about two weeks in lakes and rivers, and five to ten days in the atmosphere.

Groundwater can stay polluted for several thousand years.

The 250 million U.S. residents living today have access to about the same amount of water as U.S. residents did 200 years ago, when the population was four million.

If present consumption patterns continue, two out of every three persons on Earth will live in water-stressed conditions by the year 2025. (THAT’S ONLY 23 YEARS!).



Forty-five percent of all listed threatened and endangered species live in fresh water.

The rate of extinction of North American fish has doubled over the course of this century.

Only two percent of America's rivers remain free-flowing and relatively undeveloped.

Freshwater use is growing at 2.5 times the population growth.

With 69%, Agriculture is the largest user of global freshwater.
Compared with industrial and municipal use.
This can increase in some countries to up to 98% in dry arid climates.

Rice, wheat and cotton at 58% of the world-wide irrigated area are main consumers of freshwater.
Of these three crops, rice is the most important, on a global scale, followed by wheat and cotton.

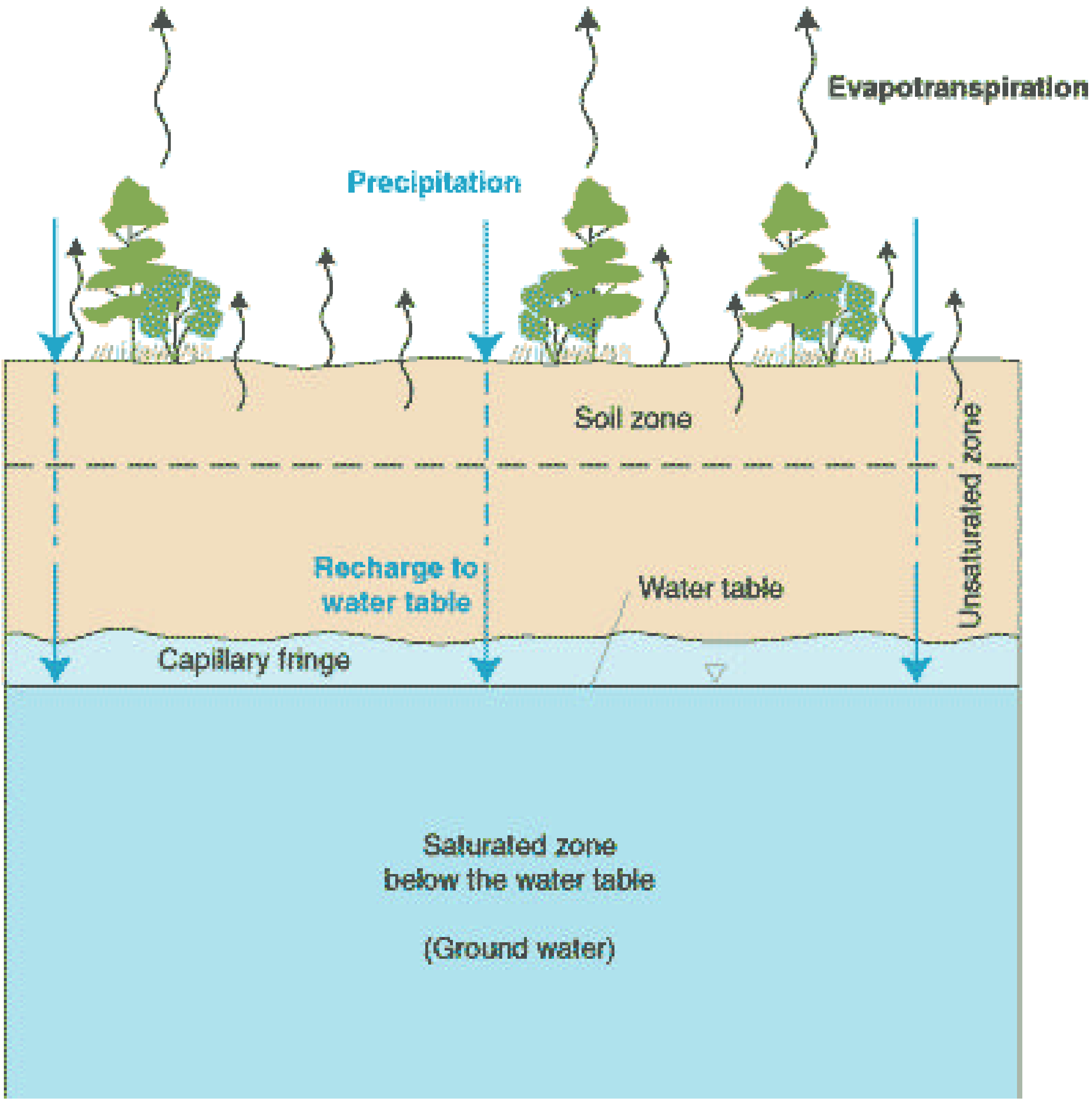
LOSS OF WETLANDS

HUMAN IMPACTS

drainage
dredging and stream
channelization
deposition of fill material
diking and damming
overgrazing by domesticated animals
discharge of pollutants
mining
alteration of hydrology

NATURAL THREATS

erosion
subsidence
sea level rise
droughts
hurricanes and other storms
overgrazing by wildlife

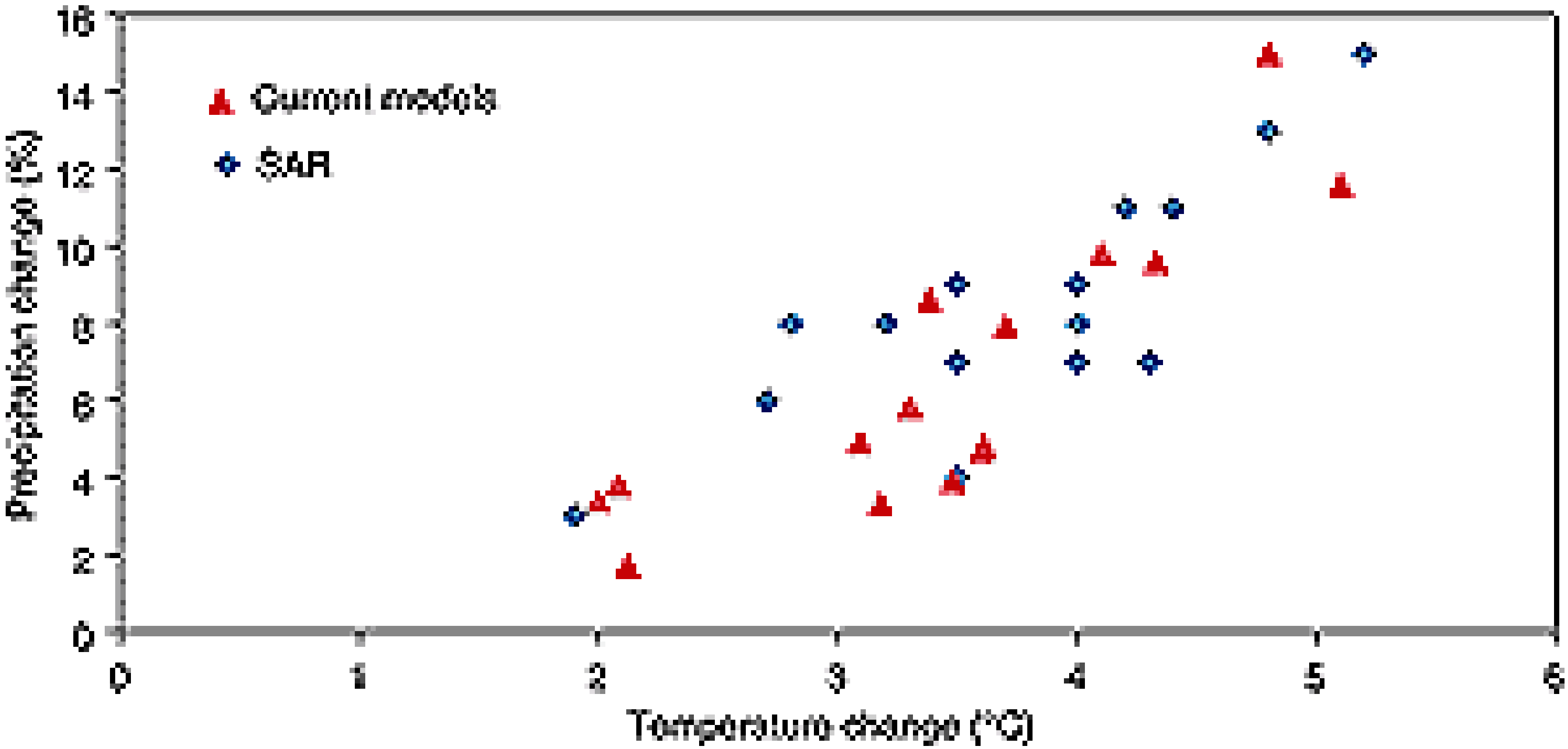


GROUNDWATER RECHARGE

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Climate Change 2001: The Scientific Basis

"Increasing global surface temperatures are very likely to lead to changes in precipitation and atmospheric moisture, because of changes in atmospheric circulation, a more active hydrological cycle, and increases in the water holding capacity throughout the atmosphere. Atmospheric water vapour is also a climatically critical greenhouse gas, and an important chemical constituent in the troposphere and stratosphere."



GCM experiments suggest that global-average annual mean precipitation will increase on average by 1 to 3%/°C under the enhanced greenhouse effect

The temperature-moisture feedback and implications for precipitation and extremes

With increasing temperature, the surface energy budget tends to become increasingly dominated by evaporation, owing to the increase in the water holding capacity of the boundary layer. The increase of evaporation is not strictly inevitable (Pierrehumbert, 1999), but it occurs in all general circulation models, though with varying strength.

Simulated evapotranspiration and net atmospheric moisture content is also found to increase (Del Genio et al., 1991; Trenberth, 1998), as is observed to be happening in many places (Hense et al., 1988; Gaffen et al., 1992; Ross and Elliot, 1996; Zhai and Eskridge, 1997).

Globally there must be an increase in precipitation to balance the enhanced evaporation but the processes by which precipitation is altered locally are not well understood. Over land, enhanced evaporation can occur only to the extent that there is sufficient soil moisture in the unperturbed state. Naturally occurring droughts are likely to be exacerbated by enhanced potential evapotranspiration, which quickly robs soil of its moisture.

Because moisture convergence is likely to be proportionately enhanced as the moisture content increases, it should lead to similarly enhanced precipitation rates. Moreover, the latent heat released feeds back on the intensity of the storms. These factors suggest that, while global precipitation exhibits a small increase with modest surface warming, it becomes increasingly concentrated in intense events, as is observed to be happening in many parts of the world (Karl et al., 1995), including the USA (Karl and Knight, 1998), Japan (Iwashima and Yamamoto, 1993) and Australia (Suppiah and Hennessy, 1998), thus increasing risk of flooding.

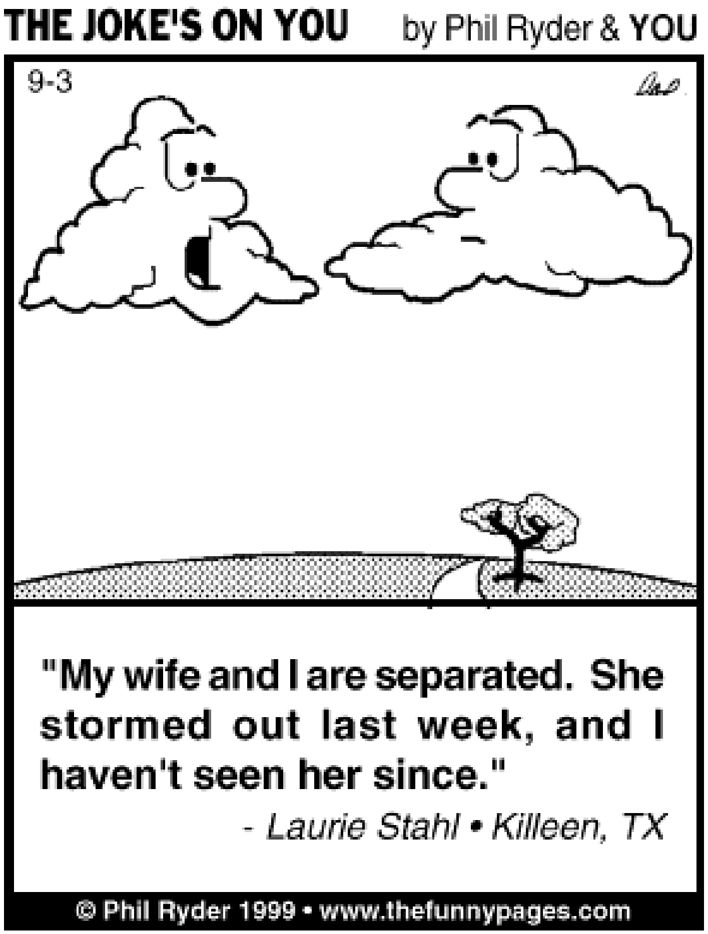
However, the overall changes in precipitation must equal evaporation changes, and this is smaller percentage-wise than the typical change in moisture content in most model simulations (e.g., Mitchell et al., 1987; Roads et al., 1996). Thus there are implications for the frequency of storms or other factors (duration, efficiency, etc.) that must come into play to restrict the total precipitation. One possibility is that individual storms could be more intense from the latent heat enhancement, but are fewer and farther between (Trenberth, 1998, 1999).

These aspects have been explored only to a limited extent in climate models. No studies deal with true intensity of rainfall, which requires hourly (or higher resolution) data, and the analysis is typically of daily rainfall amounts. Increases in rain intensity and dry periods are simulated along with a general decrease in the probability of moderate precipitation events (Whetton et al., 1993; Cubasch et al., 1995; Gregory and Mitchell, 1995; Mearns et al., 1995; Jones et al., 1997; Zwiers and Kharin, 1998; McGuffie et al., 1999). For a given precipitation intensity of 20 to 40 mm/day, the return periods become shorter by a factor of 2 to 5 (Hennessy et al., 1997). This effect increases with the strength of the event (Fowler and Hennessy, 1995; Frei et al., 1998).

Accordingly, it is important that much more attention should be devoted to precipitation rates and frequency, and the physical processes which govern these quantities.

Aerosol Impact on Liquid-Water Content and Cloud Amount

And Their Lifetimes…. Not all Clouds Rain……

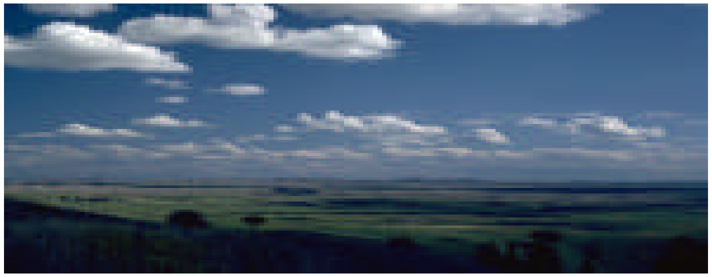


TYPES OF CLOUDS

Cirrus (curly or fibrous)

Stratus (flat or layered)

Cumulus (puffy-cottonball)



NAMES OF CLOUDS

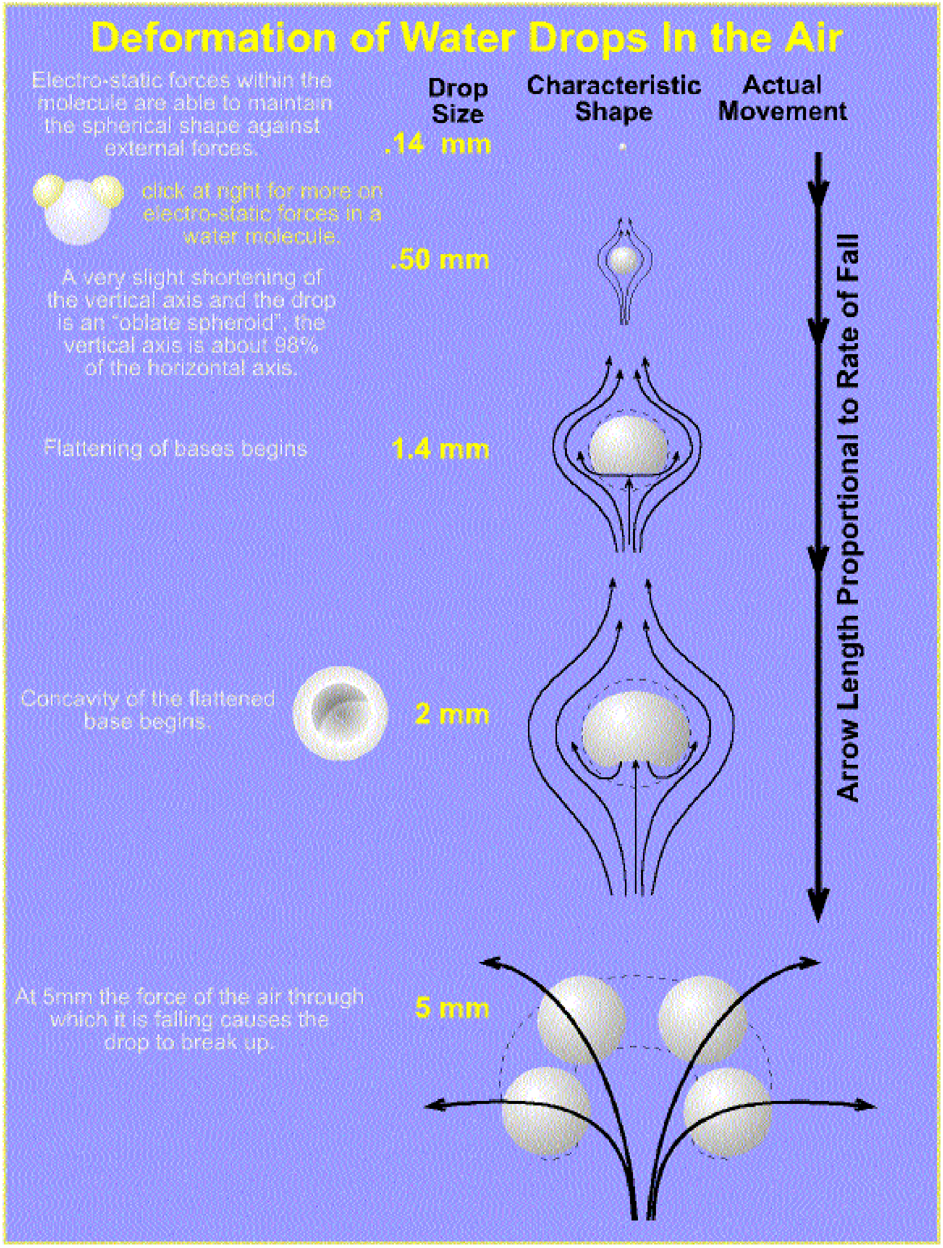
Cirro- high clouds -bases above 20,000 feet.

Alto- mid-level clouds, 6000 and 20,000 feet.

Nimbo- at beginning, or *nimbus*- at end – precipitating!

Cloud Type	Appearance	Altitude
Cumulonimbus	Thunderheads	Near ground to > 50,000 feet
Cirrostratus	Thin, wispy, above thunderheads	> 18,000 feet
Cirrus	Thin, often with "mare's tail"	> 18,000 feet
Cirrocumulus	Small puffy clouds	> 18,000 feet
Altostratus	Thin, uniform, sometimes "corduroy" appearance	6,000-20,000 feet
Altocumulus	Medium-sized puffy clouds	6,000-20,000 feet
Stratocumulus	Broad and flat on the bottom, puffy on top	Below 6,000 feet

Cumulus	Puffy clouds	Below 6,000 feet
Stratus	Uniform, thick to thin layered clouds	Below 6,000 feet
Fog	Cloud hitting the ground	Ground and up!



Cloud Drops Need Support!

TYPICAL LARGEST DROP SIZES FOUND IN CLOUDS

Cloud Type	LARGEST DROP SIZE mm	in	μm	UPDRAFT NEEDED TO KEEP ALOFT cm/sec	miles/hr	inches/sec
Cumulonimbus	0.076	0.003	76	9	0.20	3.52
Towering Cumulus	0.067	0.003	67	6	0.13	2.29
Fair Weather Cumulus	0.016	0.0006	16	0.4	0.009	0.16
Altocumulus	0.010	0.0004	10	0.2	0.004	0.07
Stratocumulus	0.008	0.0003	8	0.07	0.002	0.03
Nimbostratus	0.043	0.002	43	5	0.11	1.94

TYPICAL RAINDROP SIZES

Light Stratiform Rain (.04'' per hour)

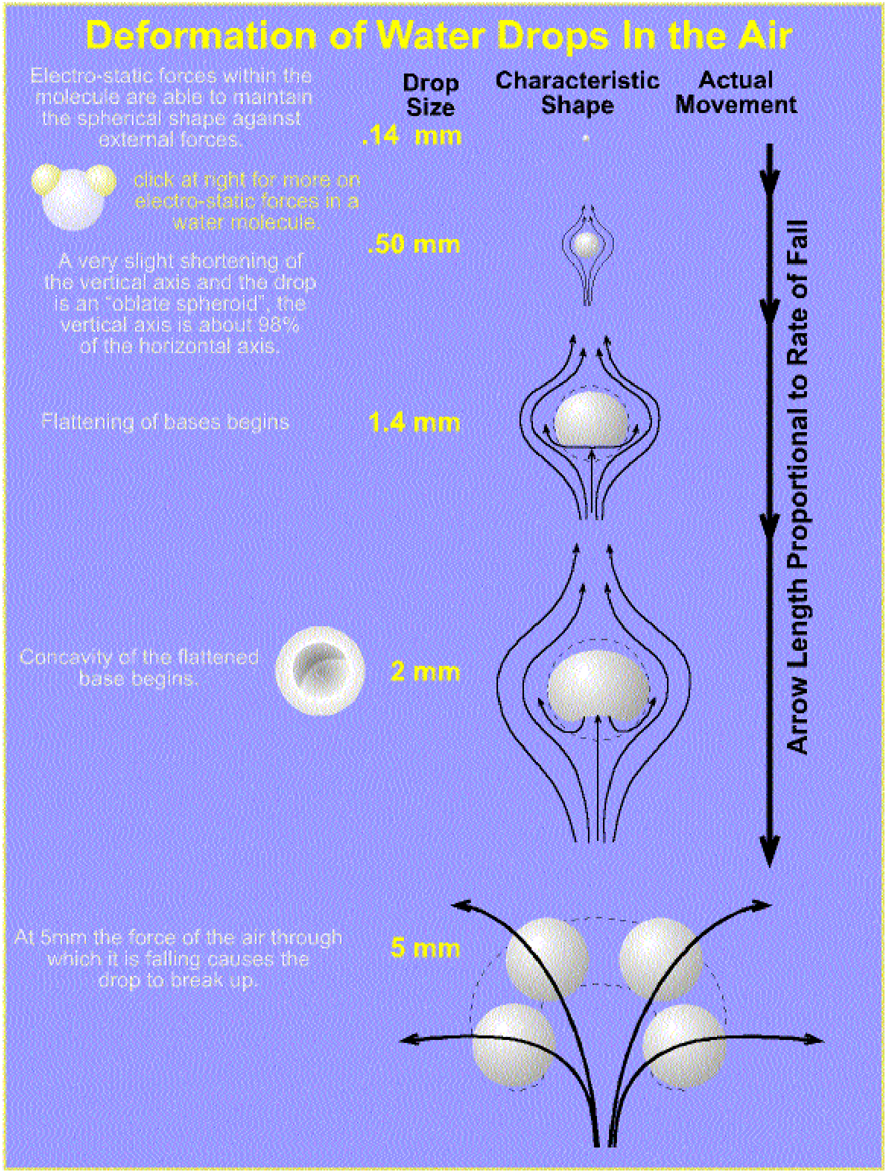
	Drop Size		Terminal Velocity	
	mm	in	$m\ s^{-1}$	$miles\ hr^{-1}$
Small Drop	.5	.02	2.06	4.6
Large Drop	2.0	.08	6.49	14.4

Moderate Stratiform Rain (.25'' per hour)

	Drop Size		Terminal Velocity	
	mm	in	$m\ s^{-1}$	$miles\ hr^{-1}$
Small Drop	1.0	.04	4.03	8.9
Large Drop	2.6	.10	7.57	16.1

Heavy Thundershower (1.0'' per hour)

	Drop Size		Terminal Velocity	
	mm	in	$m\ s^{-1}$	$miles\ hr^{-1}$
Small Drop	1.2	.05	4.64	10.3
Large Drop	4.0	.16	8.83	19.6
Largest Possible Drop	5.0	.20	9.09	20.2
Hailstone	10	0.4	10.0	22.2
Hailstone	40	1.6	20.0	44.4



Limitation on water droplet

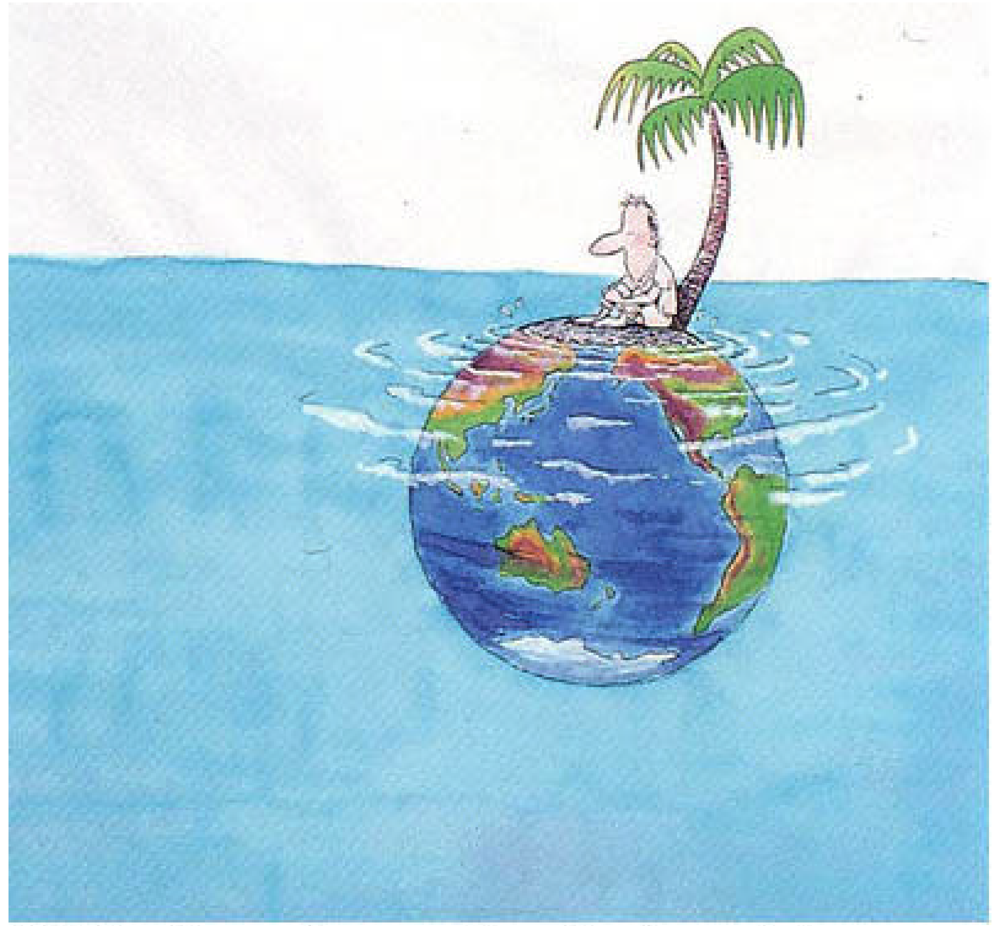
Size depends upon liquid water properties..

HAIL is Frozen Water

Can get very large!

And have strange shapes!

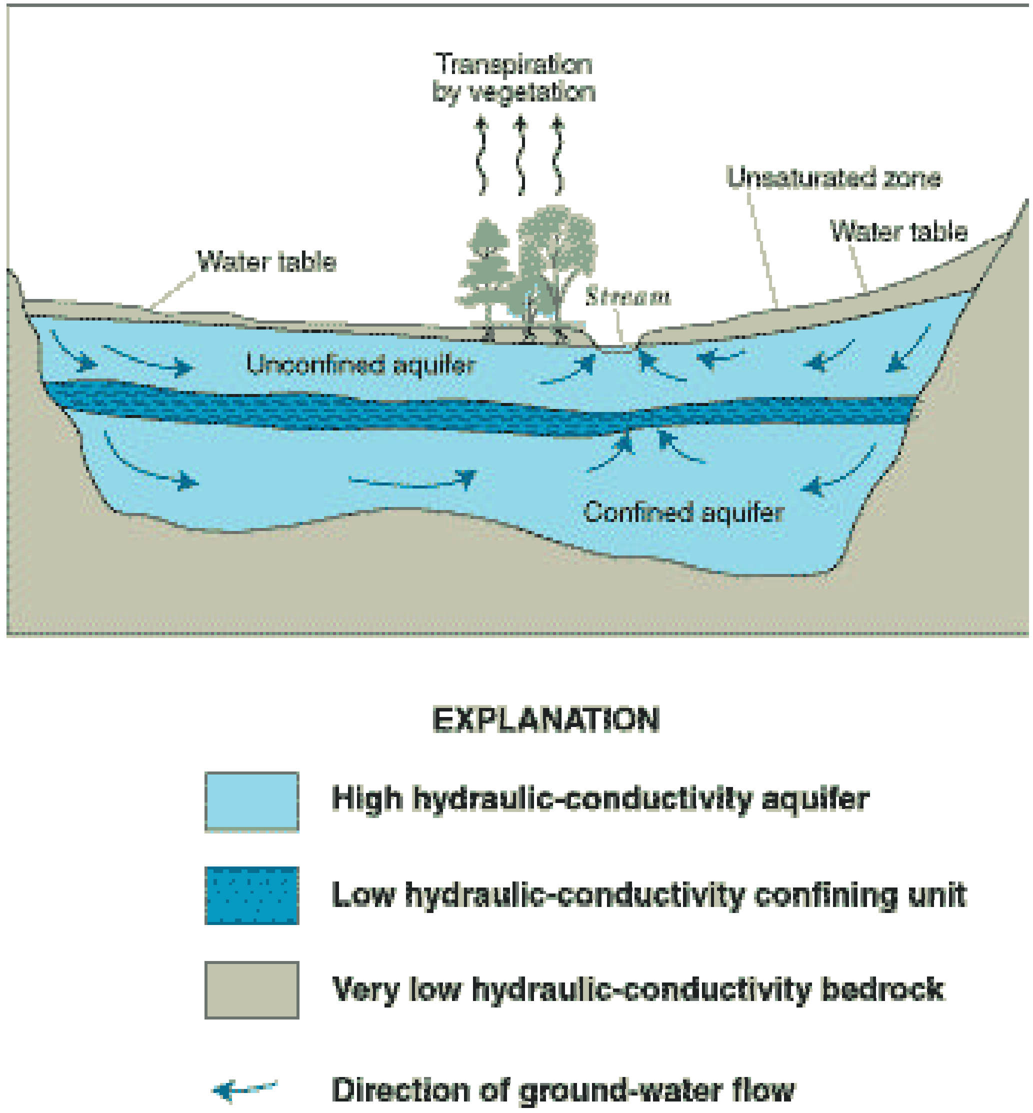
Rain falls on the desert as the faucet charmer blows horn.



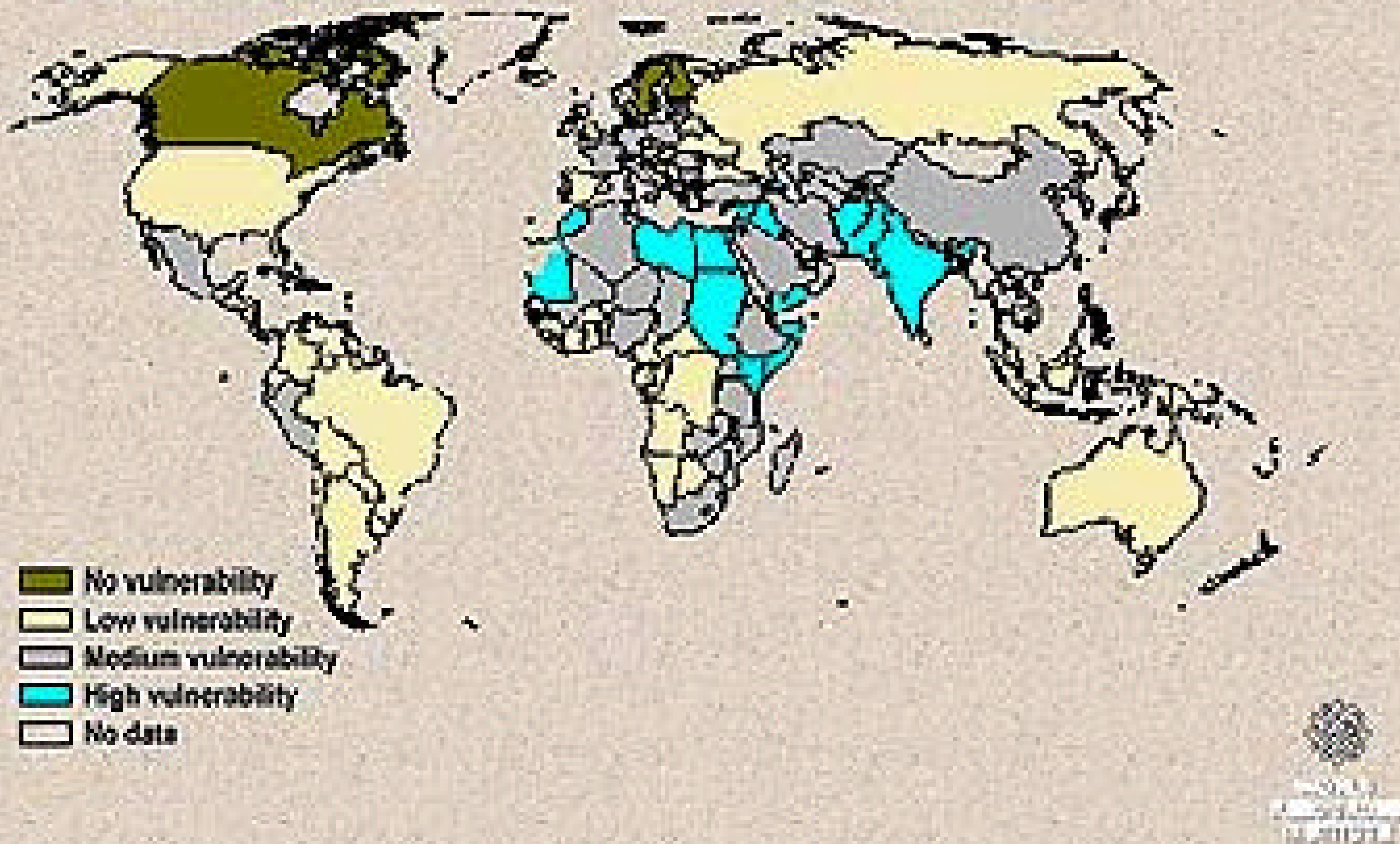
Will there be any place remaining where human beings can live? Land areas are steadily disappearing.

SO BIG QUESTIONS ARE.. WHERE AND HOW MUCH!

GROUNDWATER IS LIMITED RESOURCE



Low-Income Nations Are Especially Vulnerable to Water Scarcity




IS THERE ANY LIMIT TO THIS EL NIÑO STUFF.
GUESS NOT... THEY'VE GOT ICE ON THE MOON.

BY BUNNY HOEST AND JOHN REINER

Laugh Parade®

"But what if it's just *El Niño*?"

"MR. NOAH, DON'T YOU THINK THE PROPHESIES OF A GLOBAL CLIMATE CHANGE ARE A BIT EXAGGERATED?"

www.coaps.fsu.edu/lib/climatoons

COAPS

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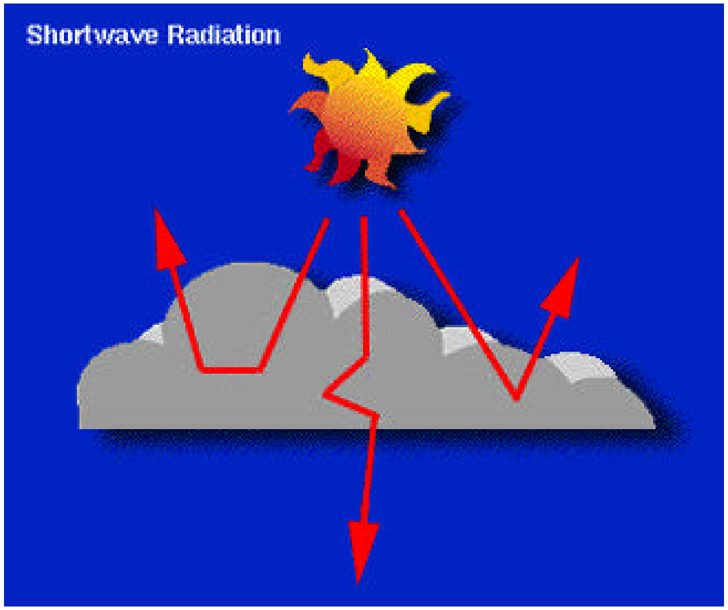
Key Questions:

Cloud Formation Rates – Cloud Condensation Nuclei

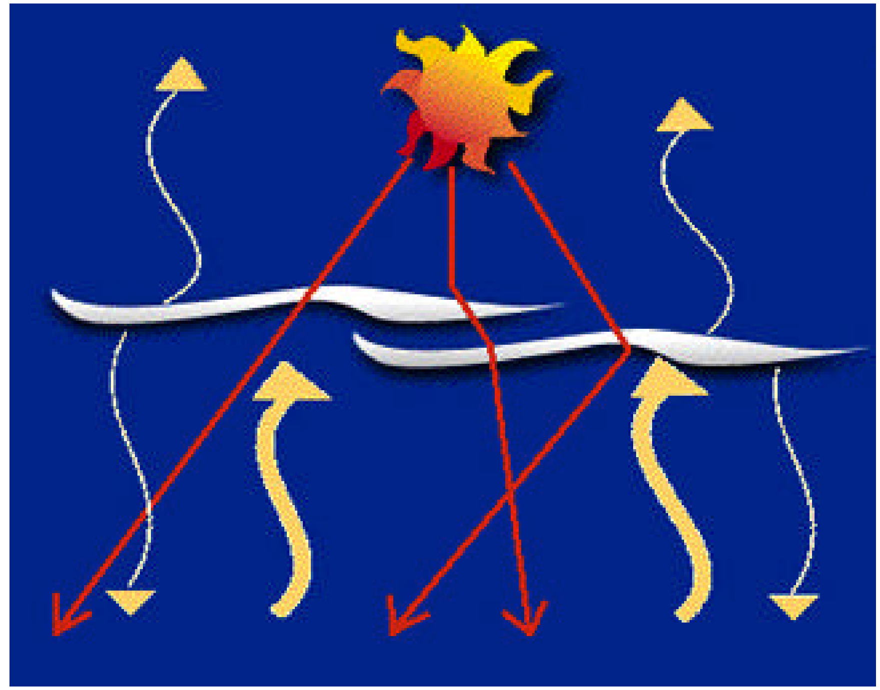
Natural vs. Man Derived Aerosols – More or Less Clouds

Cloud Feedbacks – Where you place the cloud will determine if it cools (scattering) or heats (IR absorption).

Local Scale Effects

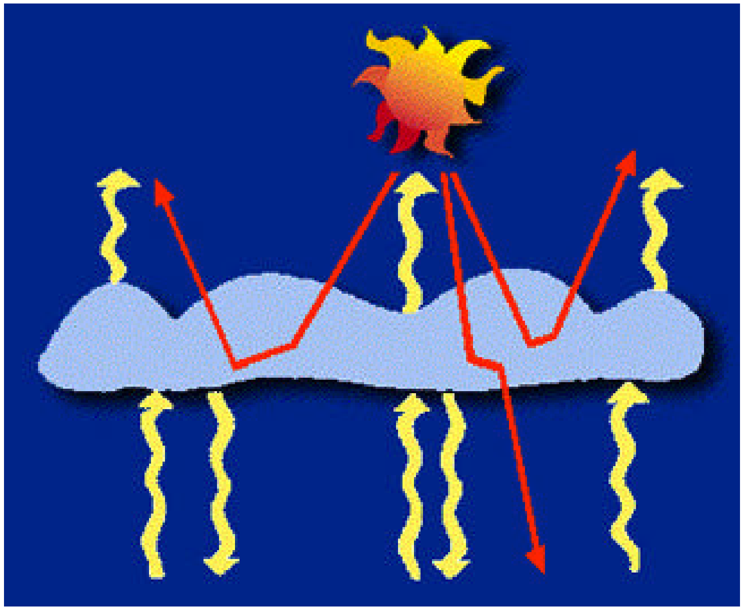


Albedo - Shortwave

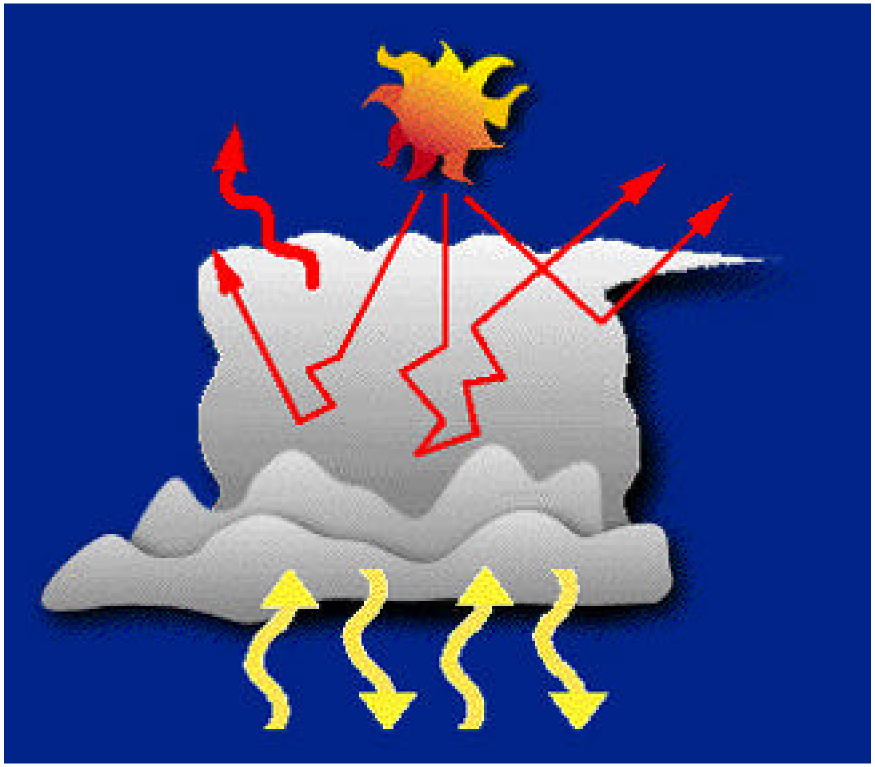


High Cloud – IR Trapping

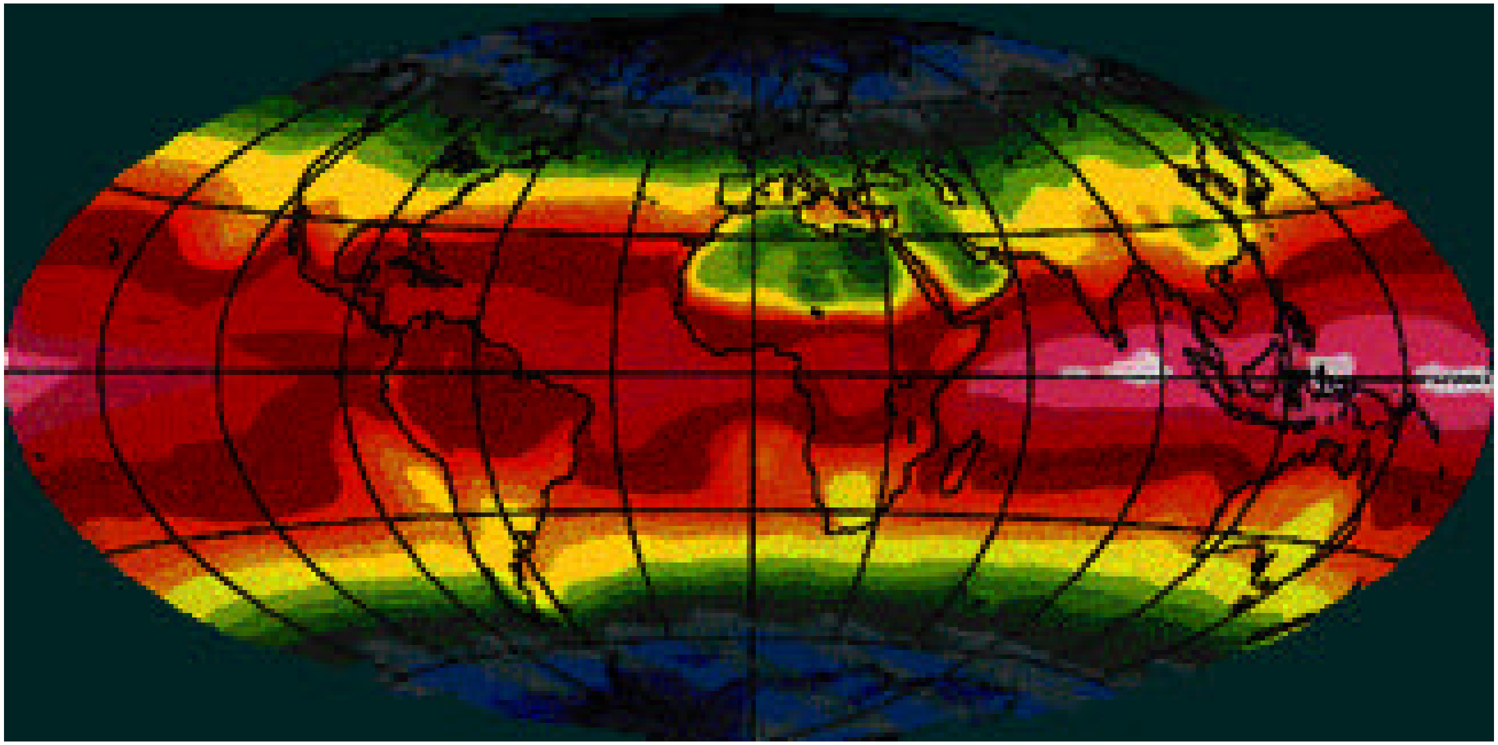
Low Clouds – Do Both!



Stratus



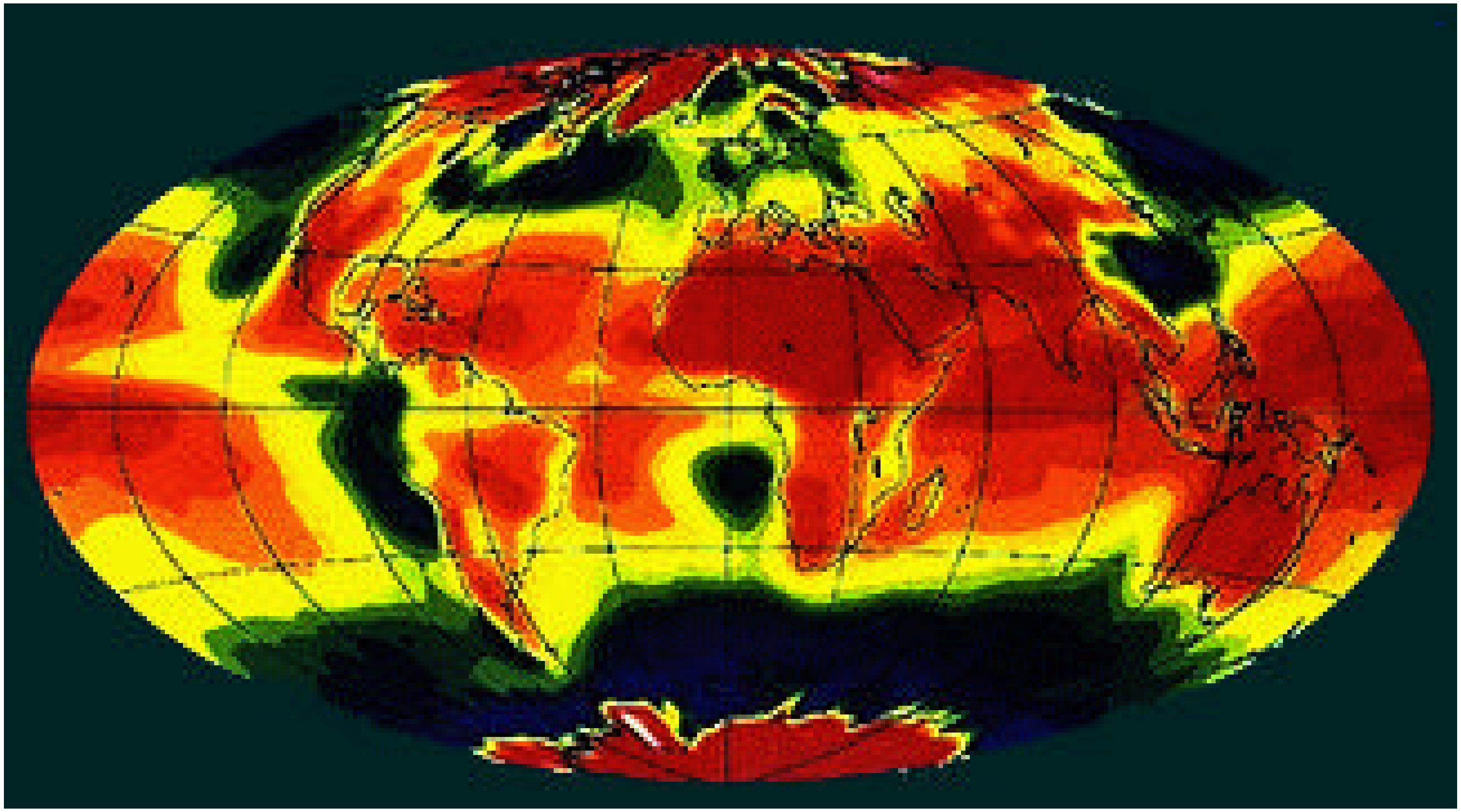
Deep Convective Cumulus



Annual Net Radiation – 1985-1986

Reds, orange are positive (heating-low latitudes)

Greens and blue are negative (cooling- high latitudes)

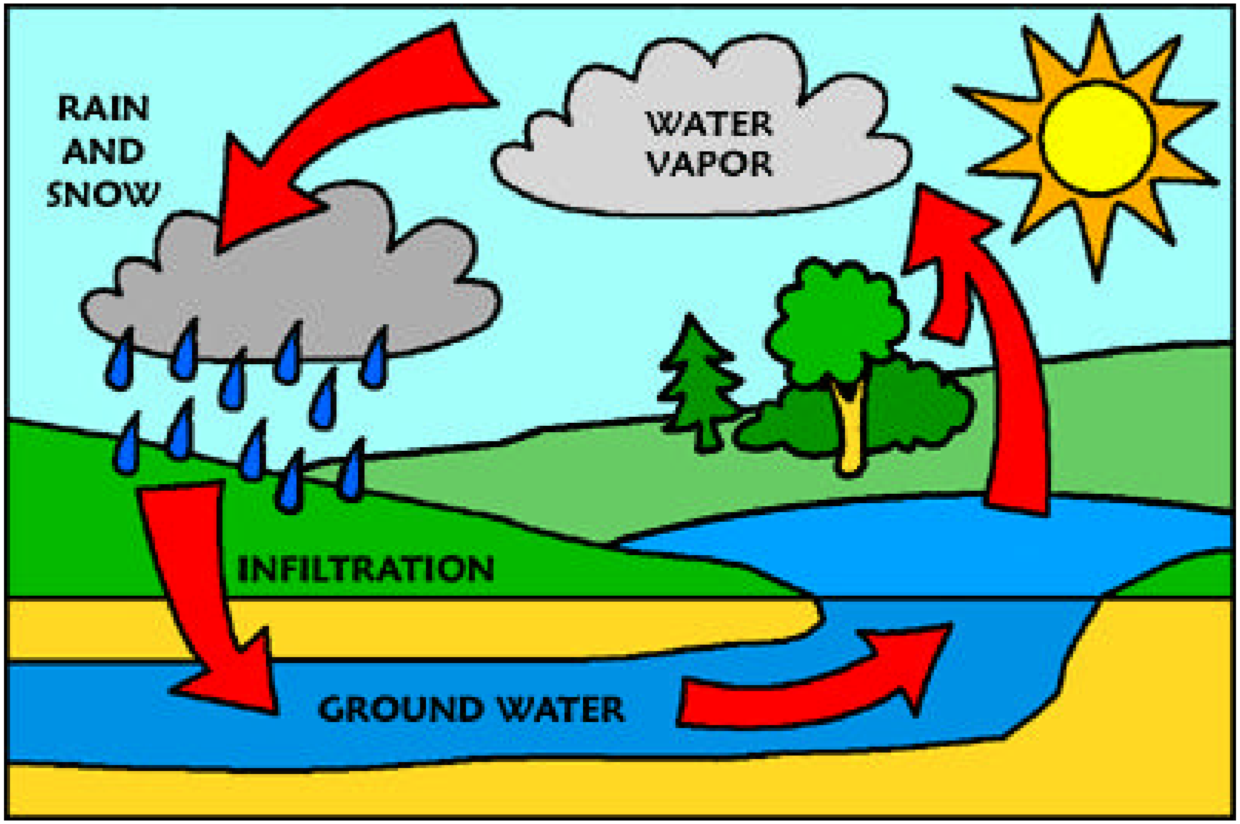


Annual Net Cloud Radiation Forcing 1985-1986

Heating is due to trapping of IR by clouds.

Cooling is due to albedo effects.

Better Understanding of Cloud Processes and the Role of ECOSYTEMS



Need to be Aware of the Problem, Understand the System, and Plan Accordingly…

Plenty of Work – DOE HYDROLOGY INITIATIVE

Acknowledgement

DOE Global Change Education Program

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Mr. Peter Lunn

Questions?